and Horsburgh's Modern Instruments and Methods of Calculation, by C. C. Grove; Longley's Tables and Formulas, revised edition, by Joseph Lipka; Enriques' Vorlesungen über projektive Geometrie, second German edition, by A. Emch; Miller's Descriptive Geometry, Armstrong's Descriptive Geometry, and Grossmann's Darstellende Geometrie, by Virgil Snyder; "Notes;" and "New Publications."

SPECIAL ARTICLES

AN APPARENT LATERAL REACTION BETWEEN IDENTICAL PENCILS OF LIGHT WAVES, CROSSING EACH OTHER AT A SMALL ANGLE[1]

1. *Methods.*—To exchange the component beams in the interferometer, to mutually replace the two pencils which interfere, is not an unusual desideratum. To replace two pencils of component rays travelling more or less parallel to each other, by pencils more or less normal to each other, to be able to operate at the point of intersection of corresponding pencils of rays from the same source, crossing at any angle, may be of interest in a variety of operations and may even suggest novel experiments.

In Fig. 1, I have sketched one of many forms of apparatus of the kind in question, with which I have recently been working. A beam of parallel rays from a collimator, L, impinges on the reflecting plate grating G. The diffracted pencils a, b, are reflected by the opaque mirrors n and m into b' and a', to be again reflected by the opaque mirrors M and N into the pencils b'' and a''. These impinge on the plate grating G', so placed that both pencils are diffracted along the same direction $G'T$, into the telescope at T.

If now the opaque mirrors m, n, M, N, are appropriately rotated, the parallel component beams $GmMG'$ and $GnNG'$ may be replaced by $GmNG'$ and $GnMG'$, respectively, which cross each other at c, while the pencils impinging at G' have been exchanged.

There is an essential difference in these two cases. Whereas in the case of parallel rays, a', and b', the double diffraction is an increment of either, in the case of the crossed rays, a and b, it is a decrement and the system tends to become achromatic. In the latter case one should suppose that homogeneous light and a wide slit only could be used in the interferometer. But this is not so.

2. *Results.*—The reflecting gratings with large dispersion constants in my possession waste too much light and the work is thus burdensome. The following results were therefore investigated with a good ruled transmitting grating, adjusted to secure the double diffraction of Fig. 1 in a single grating. This simplifies the method and the interferences are much more expeditiously found. The rays in such an apparatus must cross in the glass plate of the grating at c.

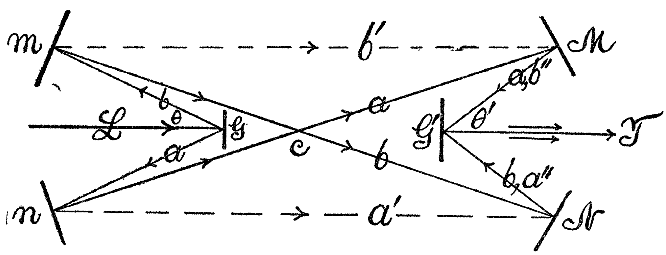


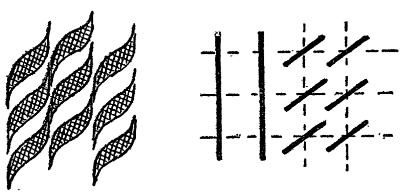
Fig. 1.

In the case of parallel rays Nn, Mm, white light and a fine slit, I obtained the linear phenomena of reversed spectra as usual. On using homogeneous light and a wide slit superb interferometer fringes were obtained. In every instance these are parallel striations crossing the whole field *uniformly.* They may easily be made coarser or finer, or rotated at pleasure, but a given field never shows independent groups; *i. e.*, there is no second periodicity

[1] Work done on a grant from the Carnegie Institution of Washington, D. C.

distinct from the first. In the case of crossed rays mN and nM, however, a uniformly striated field is only incidental. There is always a second periodicity present, distinct from the first, even if concealed. The striations are grouped in parallel strands. It is now quite possible to obtain the linear phenomenon with a wide slit and the occurrences, when homogeneous light and the wide slit are used, are merely a rhythmic reproduction of the linear phenomenon, parallel to the slit; *i. e.,* transverse to the spectrum.

To make this clearer, suppose the original or regular striations are vertical and that sodium light is used. Then the typical pattern is of the kind shown in Fig. 2*a*. It looks like a parallel set of thick twisted cords, hung side by side and equidistant. It is often much more complicated, though adhering to this design.



a *b* *c*

FIG. 2.

The evolution of this pattern is obtainable on moving one of the slit images in the field in different amounts micrometrically over the other, keeping the longitudinal axes of the spectra in coincidence. Then if the fringes are originally nearly vertical apparently uniform striations, figure 2*b*, they change by rotation into the form figure 2*c*, and at the same time enlarge. In other words, the lines *b* consist of individual parts, behaving similarly but independently, as if they were a set of magnetic needles. The same results may be obtained with the single strand of the linear phenomenon and white light and here the rotation may be carried through nearly 180°, between infinitely small sizes. It is fairly tumbling in its mobility when of maximum size and horizontal. Again, suppose the original regular fringes to have been horizontal and apparently uniform. Then if the phenomenon is made of maximum coarseness (there are two positions of the grating for which this occurs), on slightly passing one slit image of the other, to different degrees, micrometrically, the appearance presented is given in Fig. 3.

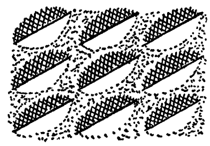


FIG. 3.

The fringes have become nodules, half black and half brilliant, strung transversely like bean-shaped beads on parallel strings and hung vertically against a neutral (non-interfering) yellow background of sodium light. In incidental cases the black shadows may be a line, and the field is then an apparently uniform coarse grid; but generally they are separated as in Fig. 3. Sometimes the central strand is strongest and the intensity diminishes on the right and the left. More frequently the two central strands are equally strong. Five or six strands may be present. On moving the mirror M parallel to itself, these strands move to right or to left as a whole, in accordance with the equations of displacement interferometry. In fact, in view of the individuality of the strands, the apparatus is a useful displacement interferometer.

The occurrence of these parallel strands for crossed rays and homogeneous light is difficult to explain. I have tried a great variety of things (slightly wedge-shaped compensators and other methods of superposing special interferences, etc.) to produce them with parallel rays mM and nN, or to break them with crossed rays mN and nM, without avail. There is no focal plane effect, nor any polarization effect. It is therefore necessary to confront the case, at its face value, as in Fig. 4. Here S and S' are the traces of two vertical, longitudinally coincident, reversed spectra, drawn apart for distinction, the region of the D lines only being used. The light is homogeneous to this extent and the slit wide, so that there is oblique incidence. Then every point of S should (on adjustment) interfere with every point of S', the result showing as a

uniformly striated field in the telescope. This is emphatically the case for the parallel rays, b' and a'; but with the crossed rays a and b

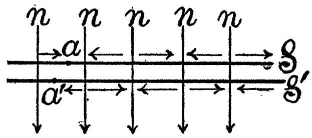


Fig. 4.

the interference is confined to the rays in the equidistant positions, n, in Fig. 4, and midway between them the field is a neutral yellow. In other words between the rays n, the rays are displaced laterally as shown by the arrows (recalling the arrangement of nodes in acoustics), so that corresponding rays a and a' for instance, do not coincide and hence can not interfere, the region aa' (Fig. 4) remaining neutral. In Fig. 5, the rays crossing at a vanishing angle have been shown for three ray filaments and the transverse arrows indicate the directions in which the rays have been urged, laterally. Naturally I am merely stating the case as suggested by the results.

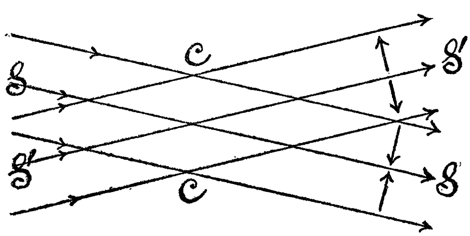


Fig. 5.

One may argue that there may be a secondary periodicity in the grating. But why does it not appear at all in the case of parallel pencils, when it is so obtrusive in the case of crossed pencils of rays? Again the interferences are unquestionably due to D_1 and D_2 light, simultaneously. If the grids in these two cases should be at a slightly different angle to each other, their superposition would give something like the observed phenomenon apart from details. With white light the linear phenomenon would eventually become achromatic. But why should lines so close together as D_1 and D_2 show any appreciable difference of angle in their interference pattern? Intersecting interference grids, moreover, can be produced by other methods and always betray their origin. The final inference is that suggested by Figs. 4 and 5, that homogeneous rays on crossing (here in a medium of plate glass) may exert a lateral influence on each other, to the effect that identical rays emerging from the crossing are arranged in equidistant nodal planes according to Fig. 4.

Carl Barus

Brown University,
Providence, R. I.

ANNUAL MEETING OF THE CHICAGO ACADEMY OF SCIENCES

On the evening of Tuesday, January 11, the annual meeting of the Chicago Academy of Sciences was held at the Academy building in Lincoln Park, Chicago.

The guest of honor and chief speaker was Director Frederic A. Lucas, of the American Museum of Natural History, and his address was entitled "The Service of the Museum to the Public."

The usual reports were received from the officers of the academy, and the results of the annual election were read. The officers for the ensuing year are: *President*, John M. Coulter; *First Vice-president*, Henry Crew; *Second Vice-president*, Stuart Weller; *Secretary*, Wallace W. Atwood; *Treasurer*, Henry S. Henschen.

Following the business meeting the members and guests were invited to inspect the new exhibit, which extends through the central portion of the main museum floor. It consists of one large case, 75 feet long and 20 feet wide. In this case, and supported from the ceiling, fifty-six of the larger birds of the Chicago region were installed as in flight. The exhibit is viewed from the main floor, and is 8 to 10 feet above the level of the eye, so that the birds are seen much as they might be under fortunate circumstances out-of-doors. One hundred and four habitat groups have now been installed in the Academy Museum to illustrate the natural history of the Chicago region. The birds, flowers, insects, reptiles and mammals are represented, and with the completion of this plan the museum will be unique in America, and have a special educational effectiveness.

Announcement was also made of the following course of open lectures: